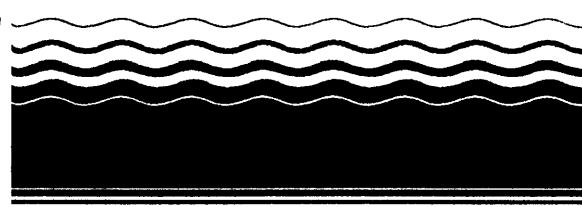




SITE

**SUPERFUND INNOVATIVE
TECHNOLOGY EVALUATION**



Demonstration Bulletin

Hydraulic Fracturing of Contaminated Soil

***Risk Reduction Engineering Laboratory and
The University of Cincinnati***

Technology Description: Hydraulic fracturing is a physical process that creates fractures in silty clay soil to enhance its permeability. The technology, developed by the Risk Reduction Engineering Laboratory (RREL) and the University of Cincinnati, creates sand-filled horizontal fractures up to 1 in. in thickness and 20 ft in radius. These fractures are placed at multiple depths ranging from 5 to 30 ft below ground surface (bgs) to enhance the efficiency of treatment technologies such as soil vapor extraction, *in situ* bioremediation, and pump-and-treat systems.

The fracturing process (see Figure 1 below) begins by using a hydraulic jet to cut a disk-shaped notch extending 0.5 ft from the borehole wall. Water is injected into the notch until a critical pressure is reached and a fracture is formed. A proppant composed of a granular material (sand) and a viscous fluid (guar gum and water mixture) is then pumped into the fracture at a rate of 16 to 24 gal/min. After pumping, the sand holds the fracture open while an enzyme additive breaks down the viscous fluid. The process is repeated at greater depths to create a stack of multiple, sand-filled hydraulic fractures.

The aboveground equipment includes a mixer, a slurry pump, and gel storage tanks. The mixer continuously blends guar gum gel, water, enzyme, and sand. The slurry pump is used to transfer this mixture to the fractured area. The fracture aperture can be estimated by measuring the ground uplift in the vicinity of the borehole. A Ground Elevation Measuring System (GEMS), which uses a laser and an array of sensors, was developed to measure uplift of the ground surface in real time during hydraulic fracturing.

Waste Applicability: The technology is designed for use in low permeability silty clays contaminated with organic compounds. This technology enhances other *in situ* remediation techniques such as vapor extraction and bioremediation. This technology was developed by RREL and the University of Cincinnati at EPA's Center Hill Research Facility. Factors that affect the technology's performance were studied at this facility during 1991 and 1992.

Demonstration Results: Hydraulic fracturing was demonstrated at two sites, a Xerox site in Oak Brook, IL, in conjunction

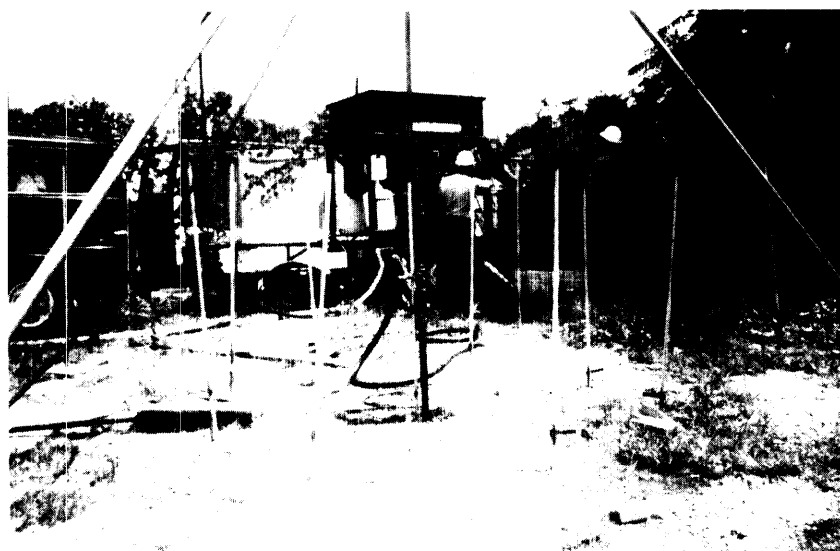


Figure 1. Hydraulic fracturing in progress, the well is located at the center of the photograph.



with a vapor extraction system, and a site near Dayton, OH, in conjunction with *in situ* bioremediation.

Xerox Site

Demonstration of this technology was conducted at the Xerox site in Oak Brook, IL, where a vapor extraction system has been operating since early 1991. The site is contaminated with ethylbenzene, 1,1-dichloroethane, trichloroethene, tetrachloroethane, 1,1,1-trichloroethane, toluene, and xylene. In July 1991, hydraulic fractures were created in two of the four wells, at depths of 6, 10, and 15 ft below ground surface. The vapor flow rate, soil vacuum and contaminant yields from the fractured and unfractured wells were monitored regularly. The site owner is continuing with contaminant removal using the fracturing technology in one more well. Results obtained to date are as follows:

- Over a 1-yr period, the vapor yield from hydraulically fractured wells was an order of magnitude greater than from unfractured wells.
- The hydraulically fractured wells enhanced remediation over an area 30 times greater than the unfractured wells.
- The presence of pore water decreased the vapor yield from wells; therefore, water infiltration into areas where vapor extraction is being conducted must be prevented.

Dayton Site

The technology was also demonstrated at a site near Dayton, OH, where *in situ* bioremediation was being used to clean up an underground storage tank spill. The site is contaminated with benzene, toluene, ethylbenzene, and xylene (BTEX), and other petroleum hydrocarbons. In August 1991, hydraulic fractures were

created in one of two wells at 4, 6, 8, and 10 ft below ground surface. Sampling was conducted before the demonstration and twice during the demonstration at locations 5, 10, and 15 ft north of the fractured and unfractured wells. Laboratory analysis included moisture content; fluorescein diacetate analysis (FDA), which measures microbial metabolic activity; number of colony forming units (CFU), which indicates the number of microbes that have a capacity to degrade hydrocarbons; total petroleum hydrocarbons (TPH); and BTEX. The flow rates of hydrogen peroxide and nutrients were also measured in these two wells. Results obtained to date are as follows:

- The flow of water into the fractured well was two orders of magnitude greater than in the unfractured well.
- The rate of bioremediation near the fractured well was 75 percent higher for BTEX and 77 percent higher for TPH compared to the rates near the unfractured well.

A Technology Evaluation Report (TER) describing the complete demonstrations will be available in early 1993.

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